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Smart Grid Technologies : Creating a Smarter World

Sankesh Parmar, Sudharshan Selveraj, Vishnu Vignesh Sundarajan

Department of Electrical and Electronics Engineering Sri Venkateshwara College of engineering
sankesh_12692@yahoo.com, sharathram29@yahoo.com, volatile.vishnu@gmail.com

Abstract – As traditional 'smart' components power systems have been key roles in power systems. Smart grid offers higher level of observation in terms of more abundant and precise information, and also brings forward more technical challenges for protection. The idea behind this paper presentation is to understand and develop smarter grids, their standards and their benefits.

We are going to discuss the current scenario in India and ways smart grid can be innovatively implemented.

Index Terms – Introduction, the idea, traditional grid, what makes a grid smart?, prime objective

INTRODUCTION

Smart Grid is a comprehensive vision to improve the reliability, efficiency, and security of the electric network. The idea encompasses technological advances that can lessen the impact humans have made on nature. An electric grid becomes "smart" when the conventional electric system is augmented with communications infrastructure, data management, automation, and control technologies that provide for improved management of power production, distribution, and consumption by power producers, distributors, and energy users.

THE IDEA

The electric grid had evolved as a result of Nicolas tesla's design in 1888. Since then the electric grid has hardly been improvised. The data-collecting and processing capabilities of the era required broadly averaged, statistical rate classifications that severely limited the timely propagation of supply and demand price signals through the system. The challenge was to curb security threats, manage the demand, consumption and wastage efficiently. Thus smart grid came into the picture. 'Smart grid' is the only solution to the challenges mentioned above.

TRADITIONAL GRID

A traditional electric grid comprised of three important components:

- **Power generation** – Major power is generated using thermal energy of coal, diesel etc. Nuclear energy, wind energy, solar energy, tidal energy etc, are in the phase of development.

- **Power transmission** – the generated power is stepped up to high voltages(132kv) using a transformer and transmitted using over head lines to substation outside cities.

- **Power distribution** –The substations step down the power from transmission level to distribution level and eventually it reaches to the consumer in the form of three phase current with 415V.

WHAT MAKES A GRID 'SMART'?

Smart grid is concept of delivering electric power to producer and consumer using digital technology to improve the efficiency, save energy and increase the transparency and reliability. Secondarily implementing a smart grid will require addressing several hurdles inherent in the utility regulatory system. In order to make a grid 'smarter' the following things are to be added :-

- An energy management system
- An IT based control system for energy transmission
- Development of intelligent transmission network monitoring and operation
- An intelligent distribution system
- Development of power equipment monitoring system
- Development of plc ubiquitous technology
- An Power semi conductors for dispersed generation and industrial inverter application
- An consumer portal system for IT based energy services

TRADITIONAL GRID (VS) SMART GRID

Current grid	Smart grid
Analogue	Digitalized
Reactive	Proactive

Manual	Automated
One price	Real time pricing
One-way	Two-way

SMART GRID CHARACTERISTICS

- **Intelligent**: this is one of the main characteristics of smart grid. This mainly aims at preventing power interruption and works autonomously. E.g. :- In a smart grid network a transformer is connected to a service network that will work round the clock. And in turn the transformer is connected to a specially designed IC which will detect a blackout according to the demand and supply ratio in that particular area. This IC will send signals every time the demand rate goes above the supply rate and will send signals to that particular area service provider. Hence the fault or blackouts caused by transformer are hence prevented and the inconvenience caused is prevented.
- **Efficiency**: smart grids help in meeting the demand without adding any additional infrastructure. In this type of power system transmission the transmission lines are much more efficient than present transmission lines. In the present lines flow of current is uni-directional. This in the case of smart grids is bi-directional. Smart grids also have an additional feature where in the availability of surplus power can be given to areas which are power deficient. And so the power generation can be reduced drastically. It also gives the values of power consumed in digital format which are much more precise than the traditional power system.
- **Accommodating**: another highlighting feature of smart grid is that it can have distributed generations and renewable energy generation standard protocol. Smart grid encourages generating power both from renewable and non-renewable resources at the same time. But its prime focus will be generating power from renewable resources. This ultimately leads to a safer, cleaner and better earth for us humans to live in. it will not have a particular area to generate power, instead will have a distributed power generation plants and hence transmission for power will be not that difficult as in traditional system.
- **Motivating**: this will help consumers in getting a more precise and accurate value compared to the traditional system. This will mean paying the exact amount of money for the actual power consumed by the consumers.
- **Opportunistic**: another important characteristic is wherein we can plug-in any number of devices at the same time and play with our innovations. This would mean a world which would be much faster than the present with more efficiency. A PHEV (plug-in hybrid electric vehicle) can now be charged at duration of maximum 1hour when compared to our traditional system. And at the same time we can carry on with our daily usage of energy at the same time.
- **Quality:** the prime focus of smart grid is to meet the requirements of the digital world in the 21st century and the future. Wherein there would be uninterrupted power supply and there would also be no power fluctuations at the time of peak demand. This would give a better living comfort and help the industries to a great extent. If this implemented in India then the industries production would fluctuate during summer and winter and as a result there won't be any deficiency in supply and hence can prevent price rise indirectly.
- **Resilient:** The future smart grid will also have safer transmission methods. Thus it will be more resistant during the time of calamities and natural disaster. The times during which power will be shut down during the time of heavy rains and people getting electrocuted due to live wires cut during rain can be drastically reduced. Laying of new transmission lines and other power equipments after a calamity can be avoided. Another important advantage is that it will help us in preventing cyber attacks because of constant monitoring. This will help the government or nation's top secret information from being disclosed to terrorists and other anti-social elements.
- **Green:** smart grids will allow us to significantly develop our mankind's vision and also attain our imagination without destroying the nature's harmony. The renewable resources will be the prime focus for power generation. This will lead to a safer and cleaner environment for our future generation to enjoy and live in.

PRIME OBJECTIVES

The main purpose of smart grid is:

- **Bring information and operational functionalities closer**: Grid operators will benefit from direct cost reductions, enhanced system reliability, and higher customer satisfaction. Direct cost reductions can come in the form of lower meter reading and servicing costs, avoided meter capital costs on existing meters, more efficient deployment of field staff as a result of better information on grid conditions, labour and non-labour operations costs savings, improvement in efficiency of billing, customer connections, and many other utility processes. Other benefits include reductions in working capital needs, reduction in bad debt expense, reduction in theft and energy losses, improved and more efficient customer service, more efficient planning and maintenance of the system, and more efficient use of back office resources. Active participation of consumer, employer, employee, government: Local

governments can benefit from higher reliability and lower duration of outages that will reduce the burden on local fire, police and other city resources that must help with such events. Greater information and control over the distribution system will also allow grid operators to assist with emergency situations, such as fires and storms, by turning off power selectively or by restoring power faster and more efficiently. Local governments are also consumers of electricity and can take advantage of the consumer-related benefits of smart grids. Elderly people are most at risk to

Extreme heat and cold when power is lost. A more reliable grid will limit the risk of outages. In addition, by helping to reduce the need for costly new generation, transmission, and distribution facilities a smart grid can help relieve upward pressure on prices to the benefit of families on low or fixed incomes.

- **Area based grid**: Grids can be set up according to the power requirement of that particular area. This will help us in receiving and distributing only the required amount of power and prevent wastage of power.

- **Decentralized energy plans**: This will help us in setting up a grid according to that particular area specification instead of planning the power distribution from a central level.

- **Eco-friendly**: The smart grid will promote e**nvironmental quality** by allowing customers to purchase cleaner, lower-carbon-emitting generation, promote a more even deployment of renewable energy sources, and allow access to more environmentally-friendly central station generation. Furthermore, the smart grid will allow for more efficient consumer response to prices, which will reduce the need for additional fossil fuel-fired generation capacity, thereby reducing the emission of CO2 and other pollutants.

And hence it acts as an alternative and green energy resources.

- **Least cost to economy**: Recent estimates show the annual cost of power interruptions in the United States of $80 billion. With total annual electric industry revenues at roughly $326 billion, these costs represent a significant burden on consumers. Reliability improvements could significantly reduce these costs. Use of smart grid technologies can help mitigate or **reduce the price of electricity** through the interaction of the demand side of the market (consumers) with the supply side (suppliers). For Example, a 2007 study estimates that in the PJM operating area alone a three percent demand reduction in the one-hundred highest prices hours of the year would produce benefits of $145-$301 million annually. This estimated does not include the value of other benefits such as reduction in capacity prices, enhanced competitiveness of the marketplace, avoided investments, and insurance against price volatility and extreme events.

- **New technology and scope for future compatibility**: Ddistribution Management Systems with ubiquitous sensors, communications, and intelligent controls provide operators with increased situational awareness of the distribution system. Early detection of unhealthy equipment can allow its replacement prior to failure. High-speed, automated line sectionalizing can quickly isolate system problems, thereby limiting the number of customers affected. Intelligent, coordinated control of distributed generation, distributed storage, circuit demand, and adjacent feeders can provide immediate backup when the primary station source is lost. These are some of the new technologies that can be implemented to increase the scope of smart grid.

Delivering the energy using digital technology: Advanced Metering Infrastructure with communicating smart meters can instantly detect power quality issues and loss of power, enabling system operators to rapidly diagnose system problems and more rapidly restore service. Smart grid hence aims at being a **process** and not a **product**.

INNOVATION CALLING

Smart grid opportunities reside in terms of technology design, engineering and development.

- **ABOUT FACTS**:

In fact, FACT (Flexible AC Transmission Systems) is somewhat of an umbrella term that encompasses several technologies designed to enhance the security, capacity

and flexibility of power transmission systems. FACTS manage to increase the existing transmission network capacity while maintaining or improving the operating margins necessary for grid stability. More power reaches consumers at a lower investment cost and with less of an impact on the environment.

- **INTEGRATED TWO WAY COMMUNICATION**

Two-way communication makes the Smart Grid a dynamic, interactive, real-time infrastructure. An open architecture creates a plug-and-play environment that securely networks grid components and operators, enabling them to talk, listen and interaction.

- **ADVANCED COMPONENTS**

Advanced components play an active role in determining the electrical behavior of the grid, applying the latest research in materials, superconductivity, energy storage, power electronics and microelectronics to produce higher power densities, greater reliability and power quality.

Examples include:

- Next-generation FACTS/PQ (power quality) devices
- Advanced distributed generation and energy storage
- Plug-in hybrid electric vehicles (PHEVs)
- Fault current limiters
- Superconducting transmission cables
- Micro grids
- Advanced switches and conductors
- Solid-state transformers

ADVANCED CONTROL METHOD

Advanced control methods monitor power system components, enabling rapid diagnosis and timely, appropriate responses to any event. They also support market pricing, enhance asset management and efficient operations, and involve a broad application of computer-based algorithms.

Examples include:

- Data collection and monitoring of all essential grid components
- Data analysis to diagnose and provide solutions from both deterministic and predictive perspectives
- "Diagnosis" and subsequent appropriate action processed autonomously or through operators (depending on timing and complexity)

- **SENSING AND MEASUREMENT TECHNOLOGIES**

Sensing and measurement technologies enhance power system measurements and facilitate the transformation of data into information to evaluate the health of equipment, support advanced protective relaying, enable consumer choice and help relieve congestion.

Examples include:

- Smart meters
- Ubiquitous system operating parameters
- Asset condition monitors
- Wide-area monitoring systems (WAMS)
- Advanced system protection
- Dynamic rating of transmission lines

IMPROVED INTERFACES AND DECISION SUPPORT

Improved interfaces and decision support will enable grid operators and managers to make more accurate and timely decisions at all levels of the grid, including the consumer level, while enabling more advanced operator training. Improved interfaces will better relay and display real-time data to facilitate:

- Data reduction
- Visualization
- Speed of comprehension
- Decision support
- System operator training

HOW ENERGY STORAGE FIT IN

The facility with which personal electronics such as cell phones and "smart phones" can store energy is a welcome fact of everyday life. When similar technologies and approaches are applied to the grid, the collective electric infrastructure will come to represent a far more reliable, secure and efficient network.

There are many benefits to deploying energy storage technologies into the nation's grid. Energy storage can provide:

1. A means to improve grid optimization for bulk power production.
2. A way to facilitate power system balancing in systems that have variable or diurnal renewable energy sources.
3. Facilitation of integration of plug-in hybrid electric vehicle (PHEV) power demands with the grid.
4. A way to defer investments in transmission and distribution infrastructure to meet peak loads (especially during outrage condition) for a time.
5. A resource providing ancillary Services directly to grid/market operators.

CONCLUSION

Smart grid is a power system with integrated automation and IT applications supporting the whole chain from production to supply, and protection plays a key roles in smart grid. Smart protection is to be provided through innovative utilization of information enabled to us by smart grid.

Humans by nature are inquisitive, this has helped us in growing and developing and so if we continue and build interest among people, smart grid can do wonders. It has a potential to change a lot of things. This could be the inception of a whole new era.

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